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(71)Applicant : NITTO DENKO CORP
(72)Inventor : UMEMOTO SEIJI
FUJIMURA YASUO
HARA KAZUTAKA
YAMAMOTO SUGURU

(54) LENS ARRAY PLATE AND ITS PRODUCTION

(57)Abstract:
PURPOSE: To provide the lens array plate of a distributed refractive index type with which even a large-area fine array plate of fine lenses can be easily produced with good array accuracy and the good uniformity of the respective lenses and which has an excellent opening rate and mass productivity and the process for production of such lens array plate.
CONSTITUTION: This lens array plate is constituted by forming a plurality of the lens regions 11 having a polygonal shape on the outer edges and a refractive index distribution in a transparent base material 1. This process for production of the lens array plate consists in irradiating the plural points of the transparent base material contg. a photosensitive refractive index control agent with a laser beam having a light intensity distribution via an optical mask having the polygonal apertures and fixing the refractive index control agent into the transparent base material, thereby forming the plural lens regions having the polygonal outer edges. As a result, the lens array plate having the lens regions of the equal refractive index distribution nearly concentrical with the polygonal outer edges and having the excellent opening race and transmission efficiency is obtd.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application]This invention relates to a lens array plate which has a polygon rim refractive-index-distribution type lens field, and is excellent in a numerical aperture, and a manufacturing method for the same.
[0002]
[Description of the Prior Art]As a refractive-index-distribution type lens array plate, conventionally, How to make a lens formed material deposit changing a presentation inside a clad formation pipe, Or a method of impregnating with the substance to which a refractive index is changed from the periphery of a rod-like lens, Or after vaporizing a different refractive-index monomer from the periphery of the resin parent of different refractive-index monomer content, heating stretching treatment of the preforming of specified length was started and carried out from the base material which obtained the residual monomer by the method of carrying out polymerization, and the stretched object was bundled, it adhered with adhesives, and what ground both sides was known.
[0003]However, require work complicated by formation, and complicated, and are inferior to pliability in a top lacking in mass production nature, the cladding layer and the adhesives layer intervened, it was deficient in the numerical aperture, was [that each lens section boils many things, changes by the application of pressure at the time of bundling a stretched object, and it is easy to become uneven] deficient in lens efficiency, such as a condensing rate, and manufacture of a large area board also had a difficult problem.
[0004]
[Problem(s) to be Solved by the Invention]The array accuracy of a minute array plate [large area / lens / detailed] is also good, and this invention makes a technical problem development of a refractive-index-distribution [which can manufacture with the drawing 1 sufficient sex of each lens easily, and is excellent in a numerical aperture and mass production nature] type lens array plate, and a manufacturing method for the same.
[0005]
[Means for Solving the Problem]A lens array plate which this invention forms two or more lens fields where a rim has refractive index distribution by a polygon into a transparent base material, and is characterized by things, And two or more places of a transparent base material containing a photosensitive refractive-index modifier are irradiated with a laser beam which has light intensity distribution via an optical mask which has a polygon opening, A manufacturing method of a lens array plate, wherein it fixes said refractive-index modifier into a transparent base material and a rim forms two or more polygonal lens fields is provided.
[0006]
[Function]By irradiating with the laser beam which has light intensity distribution, and carrying out fixing treatment of the photosensitive refractive-index modifier in a transparent base material, based on the intensity distribution of a laser beam, a difference partial to the amount of fixing of a refractive-index modifier can be given, and, thereby, refractive index distribution can be formed. In that case, since the intensity distribution of a laser beam shows Gaussian distribution usually, it can form the lens field where a refractive index changes continuously based on the Gaussian distribution.
[0007]By irradiating with a laser beam via the optical mask which has a polygon opening in the above, the maximum dense array in which the polygon rim lens field could be

formed and which the lens field adjoined can be attained advantageously, and improvement in a numerical aperture can be aimed at. The distribution state of the refractive index in a lens field can be arbitrarily controlled by the dose of the laser beam which has light intensity distribution, or scan, and the dose can be adjusted with irradiation time, the current beam position of a laser beam, the size of irradiation spot, etc. Selection whether it is considered as or or the thing which decreases to which a refractive index shall increase to the radial direction of a lens of the refractive-index modifier to be used, i.e., it is controllable by whether or or the thing which makes it increase using that to which the refractive index of a transparent base material is reduced is used.

[0008]Therefore, according to the above, can form a lens array plate efficiently by the exposure of the laser beam to a transparent base material, and it excels in mass production nature, and manufacture of a large area board is also easy. It is easy to form a uniform lens field regularly, a lens field can improve [accuracy] an array, the high-density arrangement which the lens field adjoined can be attained, and what has a large numerical aperture can be obtained. Furthermore, physical properties, such as pliability, can be easily given by proper selection of a transparent base material.

[0009]

[Example]The lens array plate of this invention forms two or more lens fields where a rim has refractive index distribution by a polygon into a transparent base material. The example was shown in drawing 1. 1 is a transparent base material and 11 is a lens field.

[0010]Manufacture of this lens array plate to two or more places of the transparent base material which contains a photosensitive refractive-index modifier, for example. It can carry out, when it irradiates with the laser beam which has light intensity distribution via the optical mask which has a polygon opening, said refractive-index modifier is fixed into a transparent base material and a rim forms two or more polygonal lens fields.

[0011]The transparent base material containing the photosensitive refractive-index modifier to be used, For example, a proper material which consists of an inorganic substance of a monomer, oligomer, resin, glass, and others, etc. is used in the combination containing at least one kind of photoactive substance, The refractive-index modifier which consists of the photoactive substance by the exposure of a laser beam is established, and what shows transparency to the wavelength light in the case of using it as a lens should just be formed.

[0012]As a transparent base material of photosensitive refractive-index modifier content generally used, the thing etc. which made the refractive-index modifier which consists of two or more sorts from which a photopolymerization nature monomer thru/or photopolymerization nature differ of monomers, photosensitive glass, etc. contain are raised into the base material which consists of polymer, glass, inorganic crystals, those composites, etc. Although the content of a refractive-index modifier may be suitably determined according to the refractive index distribution etc. which are made into the purpose, 300 or less weight sections per base material 100 weight section of refractive-index modifiers of 150 or less weight sections are made to contain it above all generally. You are made to contain a photoreaction initiator, a photosensitizer, etc. if needed by the transparent base material.

[0013]As a transparent base material, the proper thing which shows transparency to the wavelength light in the case of using it can be used as a lens. To formation of a flexible

micro-lens board, the transparent base material of a polymer system is preferred. As the polymer, for example Polyolefine, various synthetic rubbers, polyvinyl chloride, Polyester, polyamide, cellulose, polyvinyl alcohol, polyacrylic ester, polymethacrylic acid ester, polyurethane, polyurethane acrylate, epoxy acrylate, etc. are raised. The transparent base material does not need to be a solid in the stage which irradiates with a laser beam, and can be solidified by proper processing of the heat-treatment after a laser beam exposure, exposing treatment, etc. The thickness of a transparent base material shall be suitably determined according to the lens effect etc. which are made into the purpose, and, generally shall be 10 micrometers - 10 mm.
[0014]Although it hardens [a polymerization and], and the aforementioned photopolymerization nature monomer and photosensitive glass which were illustrated as a refractive-index modifier combine by adding and are established via monomers and a base material by the exposure of a laser beam, What is necessary is for there to be no limitation in particular and just to be in the state where it does not dissociate from a substrate easily, about the kind of the fixing, in this invention. A fixing state can also be reinforced if needed by a development, heat-treatment, pre-exposure processing, postexposure processing, solvent treatment, etc.
[0015]Therefore, as a photosensitive refractive-index modifier, by the exposure of a laser beam, according to the irradiation intensity for example, the proper thing which forms the refractive-index state which changes with change (distribution) of a degree of polymerization, conversion and the degree of hardening, a degree of cross linking, an addition rate, etc. can be used.
[0016]In [like / the above] the method of this invention, although change (distribution) of the refractive index in a formation lens field is given by changing the amount of fixing of a refractive-index modifier, and giving concentration distribution, the grant can perform it by the exposure of the laser beam which has light intensity distribution.
[0017]A proper laser oscillator can be used for the exposure of a laser beam according to the reaction wavelength of photoactive materials, such as a photosensitizer, a refractive-index modifier, and others, for example, a photopolymerization initiator. Preferably, the beam cross section of a circle configuration can be formed and zero-order or the primary Gaussian distribution is shown as luminous-intensity distribution. The desirable irradiation wave length of a laser beam is 200-650 nm.
Therefore, ultraviolet laser etc. can use preferably.

[0018]As an example of the laser oscillator generally used, things which oscillate the laser beam of short wavelength comparatively, such as an excimer laser, an argon laser, and a helium cadmium laser, are raised. A helium neon laser etc. can be used depending on the combination of a photopolymerization initiator or a photosensitizer. If needed, wavelength changing of the long wavelength laser, such as an YAG laser, can be carried out to the 3rd harmonics etc., and it can also be used for them.
[0019]The manufacturing installation which has arranged the laser oscillator to drawing 2 was illustrated. This consists of the optical system 6 for a scan which serves as the laser oscillation part 2, the shutter 3, the optical mask 4, and the condensing part 5 that consists of a lens, a mirror, a filter, etc. from a mirror etc. The exposure of the laser beam (arrow) to the transparent base material 7 of a processing object can be performed by condensing the laser beam oscillated from the laser oscillation part 2 via the condensing part 5,

adjusting the size of irradiation spot, and reflecting it in the transparent base material side via the optical system 6 for a scan. An irradiation position and a scanning locus are adjusted by control of the optical system 6 for a scan.
[0020]The shutter 3 is for controlling the passage to the condensing part 5 of the laser beam oscillated from the laser oscillation part 2.
As for this shutter, it is preferred that a condensing part and the optical system for a scan are interlocked with, and it can control.
The device about a personal computer can perform the control easily.
[0021]What is for the optical mask 4 controlling the exposure shape of a laser beam, and has a polygon opening in this invention is used. Thereby, a polygonal lens field is formed for a rim. The optical mask 4 which has drawing 3 - the opening [polygon / drawing 6] 41 was illustrated. Although there is no limitation in particular about the polygon which forms an opening, an isosceles triangle, a square, a rectangle, a hexagon, etc. containing an equilateral triangle are preferred, and the right hexagon like illustration is more preferred to especially drawing 5 than to the point of improvement in the numerical aperture by the maximum dense arrangement which the lens field adjoined. The opening in an optical mask does not need to be an opening and should just have a light transmittance state. The light transmittance state of an opening does not need to be uniform and may differ selectively.
[0022]The optical mask 4 can be arranged in the proper position between the laser oscillation part 2 and the transparent base material 7 of a processing object. Between the laser oscillation part 2 and the optical systems 6 for a scan is preferred, and when control of the shape of the lens field to form, etc. is also taken into consideration, between the laser oscillation part 2 and the condensing parts 5 is more preferred like drawing 2 than like the point which carries out adjacent arranging of the lens field without a crevice. As for the optical mask 4, it is more preferred than points, such as control of a formation lens field, to arrange so that the center of the opening may be as much as possible in agreement with the center of a laser beam.
[0023]A course, speed, etc. of intensity control, such as dimming, and a scan by the irradiation time of everything but the aforementioned optical mask, for example, a laser beam, intensity, the current beam position of a laser beam, the size of irradiation spot, the filter, or a transmissivity distribution type optical mask can perform control of the lens field to form. In this invention, a predetermined time exposure is carried out by un-scanning.
Therefore, the field which has a smooth curve based on Gaussian distribution etc. and where a refractive index changes continuously can also be formed, a laser beam can be made to be able to scan and arbitrary lens fields can also be formed.
In that case, the size of irradiation spot shall be about 0.01-200 mm usually.
[0024]The path of the lens field to form, thickness, a focal distance, etc. are arbitrary, and the shape of surface type of a lens field, for example, a plane, convex, concaves, those combination, etc. are arbitrary. The number of arrays and arrangement state of a lens field are also arbitrary. As described above rather than the point of the numerical aperture, it is advantageous to consider it as the maximum dense arrangement which the lens field adjoined, and the rim shared state which a part of rim of each lens field which adjoins especially drawing 7 like illustration superimposed is preferred. Formation of this arrangement state can be performed by uniting the irradiation position of a laser beam

with the size of the irradiation spot, and controlling it, for example.
[0025]The distribution state of the refractive index in a lens field can be suitably determined according to the purpose of use, the shape of surface type, etc. The shape of the ********** is so preferred that it is so close to a regular polygon that it is circularly close to drawing 7 in the inside of a rim like illustration, and the distribution state which shows a refractive-indicees line, such as concentric, further is more preferred than the point of transmission efficiency. Especially in the case of a plane lens, the quadratic curve distribution which makes the center of a lens field the peak is preferred. In that case, it can be considered as the lens field which acts in concave lens by considering it as the minimum in convex lens by making the peak concerned into the maximum. It can also be considered as the lens field which acts in aspheric surface lens by adjusting refractive index distribution. The path and thickness of a lens field, performance, a nearby distance between lens fields, etc. may determine suitably the size of a refractive index in a lens field, and the size of the refractive index difference in the distribution.
[0026]After finishing the fixing treatment of the refractive-index modifier by the exposure of a laser beam, the solvent wiping removal of the refractive-index modifier which is not established [which remains in a transparent base material] is performed as one, such as a development as occasion demands [above-mentioned], heat-treatment, exposing treatment, and solvent treatment. This solvent wiping removal can perform extracting processing by a solvent, volatilization-ized processing by heating, etc. by the proper method according to the refractive-index modifier of content.
[0027]The lens array plate of this invention can be used for an optical apparatus, an optoelectronics device, etc. for the various purpose. Especially the array plate of a detailed lens can be preferably used for the improvement in the visibility of a liquid crystal display thru/or good-ization of a display, etc. Namely, by taking out only the beam of light which penetrated the liquid crystal layer at the angle near perpendicularity thru/or it via the lens array plate from the image formation light which he follows in the various directions which penetrated the liquid crystal panel of the liquid crystal display, The fall of the contrast by a viewing angle, reversal of a display, or change of hue is controlled, and a good display can be obtained.
[0028]ten copies (a weight section.) of polymethyl acrylate obtained by carrying out example 1 solution polymerization using 20 copies of ethyl acetate for that it is the same and ten copies of tribromophenoxy ethyl acrylate (refractive index 1.56) below -- a photopolymerization initiator (IRGACURE 651 and the Ciba-Geigy make.) Mix with the 0.1 same copy below, develop the solution by the usual cast method in a dark place, and a 100-micrometer-thick film is formed, After glaring making it scan a helium cadmium laser so that it may become the maximum dense arrangement which the formation area adjoined on the exposure conditions for 2 seconds per one spot with the spot diameter of 1.2 mm via the optical mask, It was immersed into methanol, extraction removal of the unreacted tribromophenoxy ethyl acrylate was carried out, and the flexible refractive-index-distribution type lens array plate was obtained. The aforementioned optical mask has a right hexagon opening, and it has arranged this so that a laser beam center and an opening center may come concentrically between a shutter and a condensing part (drawing 2).
[0029]Comparative example 1 optical mask was not used, and also the lens array plate was obtained according to Example 1.

[0030]Heating extension of the refractive-index-distribution type rod which obtained it to it by carrying out polymerization of the mixed solution of 100 copies of methyl methacrylate and one copy of benzophenone which carried out being immersion impregnated to the rod which consists of comparative example 2 polystyrene is carried out, It was bundled after cutting the obtained fiber and it pasted up with the epoxy resin under application of pressure, and cutting removal of the both sides was carried out, optical polish of the cutting plane was carried out, and the lens array plate was obtained.
[0031]The refractive index distribution was measured with the differential interference microscope (made in Carl Zeiss Jena) about the lens area unit in the lens array plate obtained by the evaluation test example and the comparative example. The result was shown in drawing 7 - drawing 9 as a difference on the basis of the refractive index of the central part. It is a case where drawing 7 is Example 1, and is a case where drawing 8 is the comparative example 1 and drawing 9 is the comparative example 2. The horizontal distance passing through the central part [case / any / refractive index difference] between refractive-index lines, such as -0.03, was about 1 mm.
[0032]It turned out that the refractive index is changing almost continuously in Example 1 from drawing 7, and the numerical aperture was about 95%. This numerical aperture far exceeds the numerical aperture (78.5%) of the place which carried out the maximum dense arrangement of the circular lens field. A formation lens field is in the state where the rim was mostly shared by the right hexagon between adjoining fields, and, as for the refractive index distribution in an inside, a refractive-indicees line, such as concentric [circularly near], is shown. On the other hand, many portions which do not show refractive index distribution according to the comparative example 1 occupied, and the numerical aperture was about 70%%. In the comparative example 2, the refractive index distribution which consists of a refractive-indicees line, such as a hexagon etc. of what showed the numerical aperture of about 90%, is shown, and it is inferior to transmission efficiency.
[0033]
[Effect of the Invention]According to this invention, the array plate which has a lens field of refractive index distribution -- it is close to polygon rim and concentric circle -- and is excellent in a numerical aperture and transmission efficiency can be obtained. A detailed refractive-index-distribution type lens field can also improve [the drawing 1 sex of shape] an array with high precision with a laser beam method, and a flexible large area board can also be mass-produced easily.

[Translation done.]